

1 BRIEF COMMUNICATION

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3 **Seventeen “extinct” plant species back to conservation attention in Europe**

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29 **Abstract (max 70 words):**

30 Seventeen European endemic plant species were considered extinct but improved taxonomic and distribution
31 knowledge, as well as ex situ collecting activities, brought them out of the extinct status. These species have
32 been now reported into a conservation framework that may promote legal protection, in situ and ex situ
33 conservation.

34

35 **MAIN TEXT (1000-1500 words)**

36 According to the IUCN Categories and Criteria¹ “*a taxon is Extinct when there is no reasonable doubt that*
37 *the last individual has died*”. To know whether a taxon is extinct is of key importance in conservation
38 biology because an extinct species is automatically removed from conservation frameworks²; de-extinction,
39 the new frontier of conservation aimed at resurrecting or creating proxies of extinct species is currently (and
40 likely for long) only theoretical^{3,4}.

41 In their impressive work, Humphreys et al.⁵ have collated data on seed plant extinction globally, offering the
42 opportunity for detailed analysis at a regional scale. Knapp et al.⁶ updated the status of plant extinction in
43 North America starting from Humphreys’s list by correcting some inaccuracies due to a typical flaw of large-
44 scale studies, i.e. reduced resolution at a local scale. Inspired by the works of Humphreys⁵ and Knapp⁶ we
45 reviewed the status of seed plant species endemic to Europe (including the Canary Islands, Azores and
46 Madeira Archipelago) listed as extinct (EX) from several authoritative sources including scientific
47 publications, red lists and floras and found that 17 out of 36 species (i.e. 47%) should be delisted (Table 1).
48 We did not consider the subspecies level.

49 Overall, most extinct plant species endemic to Europe were native to the Mediterranean Basin biodiversity
50 hotspot. Four cases were genuine rediscoveries⁷, while in the rest delisting is due to the advance in the field
51 of taxonomy, the rectification of past erroneous identifications, and the ex situ collecting activities previous
52 to extinction in the wild (Table 1).

53 The classical reason for changing the status of an extinct species is its rediscovery due to ad hoc exploration
54 campaigns or fortunate encounters⁸. This applies to three plant species endemic to Europe (*Astragalus*
55 *nitidiflorus* Jiménez Mun. & Pau, *Ligusticum albanicum* Jáv. and *Ornithogalum visianicum* Tomm.; Table
56 1), which adds on to previous well-known cases of species rediscoveries like, for instance, *Diploaxis*
57 *siettiana* Maire⁹. It is noteworthy that plant rediscovery has happened in an area of the world well known and
58 widely explored by thousands of botanists and citizen scientists^{10,11}.

59 An important contribution to delisting extinct taxa derives from changes in taxonomic status. Seven extinct
60 species are now considered synonyms of as many extant taxa. Three plant species have been erroneously
61 identified in the past and should be ascribed to different taxa, endemic to Europe like *Galatella malacitana*
62 Blanca, Gavira & Suár.-Sant. but still occurring in the wild, or to widespread species (e.g. *Lythrum*
63 *borysthenicum* (Schrank) Litv. and *Genista triacanthos* Brot.; Table 1).

64 Although online floras, atlas and data repositories like GBIF facilitate the retrieval of up-to-date information
65 on species, distribution data rarely find their way to widespread scientific journals and are in most cases
66 published (if at all) in local journals or books, making difficult their retrieval. Table 1 could be completed
67 only thanks to the author's networks with local botanists and amateurs.

68 Two species have been subject to ex situ conservation activities before their extinction in the wild and are
69 now found in botanic gardens, i.e. *Hieracium hethlandie* (F.Hanb.) Pugsley recently reintroduced in the
70 Shetland Islands from ex situ plant material collected before its extirpation and possibly *Armeria arcuata*
71 Welw. ex Boiss. & Reut. (ex situ material preserved at the Utrecht University Botanic Gardens is being
72 compared morphologically and genetically with the type specimens to exclude that it is *A. caespitosa*
73 (Ortega) Boiss.; Table 1). These species have been therefore erroneously declared extinct when they should
74 have been considered "extinct in the wild" (EW). This also applies to seeds preserved ex situ, that can
75 prevent species extinction even when all plants have died⁴. Nevertheless, it is almost impossible to predict
76 the behaviour of banked seeds when germination is attempted. This is especially true for seeds preserved in
77 herbarium specimens like in the case of *Filago neglecta* (Soy.-Will.) DC., a taxonomically doubtful species,
78 of which a batch of seeds extracted from herbarium specimen is available, but for which viability is unknown
79 (see notes in Table 1). For some delisted species, holdings of living specimens or seeds in ex situ facilities
80 are very poor (Table 1). Living specimens may be affected by cultivation techniques that often act as
81 selective forces inducing changes in the phenotype and genotype of ex situ material with unpredictable
82 consequences when reintroduction is attempted¹². Old seed accessions may not be viable any longer, may
83 have low germinability or may not be representative of the whole genetic variability of the species¹³. In other
84 words, the occurrence of seeds in ex situ facilities may not mean that this material is available and usable for
85 restoring EW species².

86 Rehabilitation of extinct species has important implications for the conservation policy and targets of the
87 hosting countries. Species that have been synonymised with taxa of no conservation concern do not require
88 further conservation measures.

89 Species that were rediscovered or reassigned to the EW category should urgently be included in fast track
90 conservation frameworks to avoid “re-extinction”¹⁴. Such frameworks should leverage the three pillars of
91 conservation: legal protection, in situ conservation measures, and ex situ conservation activities. Legal
92 protection alone is not always enough to reduce the risk of extinction, especially for highly threatened
93 species with a restricted distribution¹⁵. Population mapping and monitoring provide key information for
94 driving active conservation measures that may include land acquisition and institution of protected areas or
95 micro-reserves¹⁶. Ex situ collections are very effective in avoiding plant species extinction, but both types of
96 ex situ collections should be implemented, i.e. living specimen and seed banking over multiple years to
97 reduce collecting pressures on wild populations (if any). Moreover, we urge institutions holding ex situ
98 material of delisted species to try propagation, renew and duplicate their collections as well as promote
99 repatriation programs. One of the aspects that emerged from this study is that in many cases institutions
100 holding the last ex situ collections of EW species were not aware of it and underestimated the resulting
101 responsibility. It is therefore important to implement and favour the integration of existing networks for
102 Biodiversity conservation in Europe and establish an urgency fund to ensure “first-aid” resources for the
103 conservation of delisted species.

104 Considering that 13 out of 16 delisted species belong to Member States of the European Union (i.e. Croatia,
105 Greece, France, Hungary, Italy, Portugal, Spain), our revision puts the EU and the single Member States in a
106 much better position towards the achievement of the Aichi Biodiversity Target 12 “*by 2020 the extinction of*
107 *known threatened species has been prevented and their conservation status, particularly of those most in*
108 *decline, has been improved and sustained*” and towards the commitments of the Global and European
109 Strategy for Plant Conservation.

110 Periodical reviews of the status of extinct species are therefore required because we demonstrated that
111 rediscoveries and knowledge improvements may produce a turnover in lists of extinct species¹⁷, with

112 implications for the conservation policy and the development of a conservation framework for the delisted
113 species.

114 Overall, we consider the delisting of 47% of extinct species in Europe like a half-full glass as other species
115 may be delisted in the future thanks to additional rediscoveries and taxonomic revisions. On one side, the
116 four species belonging to the *Ranunculus auricomus* L. complex have been recently described from
117 herbarium specimens and never searched properly in their native areas^{18,19}; the position of *Armeria arcuata* is
118 still uncertain. On the other side, this list will become longer if direct threats to several plants endemic to
119 Europe do not cease or are not removed soon.

120

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141 **Author contribution**

142 T.A. and G.A.R. conceived the idea and wrote the manuscript, Z.B. reviewed the species for Hungary,
143 Ukraine and the Balkans, I.B. reviewed the species for Greece, D.D. reviewed the species for Portugal and
144 revised the material of *A. arcuata*, P.G. reviewed the species for France, J.M.I., E.L., J.C.M.-S. reviewed the
145 species for Spain and Azores, F.B. reviewed the species for Italy, Malta and Croatia and revised the
146 taxonomy. All the authors contributed to the several versions of this manuscript, including the design of
147 Table 1.

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214 **Table 1.** List of true extinct and putative extinct species in Europe. Column "Synonym" reports the synonym
 215 of putative extinct species that have been delisted due to change in their taxonomic status; column "New
 216 status" reports the species status according to this article and a reference. Where no reference is indicated, the
 217 status derives from our original research. Column "MSB" indicates whether there are seed lots preserved at
 218 the Millennium Seed Bank of the Royal Botanic Gardens, Kew; column "ENSCONET" indicates whether
 219 there are seed lots preserved in the seed banks of the European Native Seed Conservation Network; column
 220 "BGCI" reports the number of ex situ collections reported in the Botanic Garden Conservation International
 221 database "Plant Search".

Species	Synonym	Country	New status	Reason for change	MSB	ENSCONET	BGCI	Notes
<i>Armeria arcuata</i> Welw. ex Boiss. & Reut.		POR	EW?	Likely preserved ex situ. See notes.	NO	0	1	The Utrecht University Botanic Gardens host an accession of <i>A. arcuata</i> of unknown origin. The material may represent <i>A. caespitosa</i> . DNA comparison with the type specimens is in due course. © Copyright BGCI Plant Database.
<i>Armeria neglecta</i> Girard		POR	EX ²⁰	No change.	NO	0	0	
<i>Astragalus nitidiflorus</i> Jiménez Mun. & Pau		SPA	CR ⁹	Rediscovered.	NO	0	0	The species is subject of ex situ and in situ conservation actions, but additional ex situ actions are recommended (i.e., seed accessions to be redistributed through germplasm bank networks).
<i>Carduncellus matritensis</i> Pau	<i>Carthamus matritensis</i> (Pau) Greuter	SPA	NO EX ⁹	Taxonomic revision. See column Synonym.	NO	0	0	
<i>Centaurea armoracifolia</i> Sm.	<i>Centaurea ragusina</i> subsp. <i>lungensis</i> (Ginzb.) Hayek	GRC	NO EX ²¹	Taxonomic revision. See column Synonym.	NO	0	0	The species has a very restricted distribution along the Croatian coast. This species needs urgent ex situ conservation actions.
<i>Centaurea pseudoleucolepis</i> Kleopow	<i>Centaurea margaritacea</i> subsp. <i>pseudoleucolepis</i> (Kleopow) Dostál	UKR	NO EX ²²	The species occurs in the Donetsk Region: ca. 150 K individuals ²² .	NO	0	0	This species has been photographed (2011) in Ukraine: https://www.plantarium.ru/page/view/item/9536.html . Ex situ collections at the Donetsk Botanic Garden and Gryshko Botanic Garden do not exist anymore (pers. comms. D.N. Ostapko - Donetsk Botanic Garden; A. Gnatiuk Gryshko Botanic Garden).
<i>Centaurea saxatilis</i> (K.Koch) B.D.Jacks.	<i>Centaurea raphanina</i> Sm.	GRC	NO EX ²¹	Taxonomic revision. See column Synonym.	NO	0	0	<i>C. raphanina</i> is a widespread distributed species in Greece.
<i>Centaurea tuntasia</i> Heldr. ex Halácsy		GRC	EX	No change	NO	0	0	First collected in July 1897 from a locality that is now within the urban area of Athens. Collected also in the early 20th century from a village near Athens and never found again. I. Bazos pers. obs.

<i>Euphrasia mendoncae</i> Samp.	<i>Euphrasia minima</i> DC.	SPA	NO EX ²¹	Taxonomic revision. See column Synonym.	NO	22	7	<i>E. minima</i> is a widespread species.
<i>Filago neglecta</i> (Soy.-Will.) DC.		BGM, GER, COR, FRA, ITA	EW?	Uncertain taxonomic status ²³	NO	0	1	A single accession of <i>F. neglecta</i> reported in the BGCI database PlantSearch was recovered from a 1977 herbarium specimen and stored at the Conservatoire Botanique National de Brest since 1994. © Copyright BGCI Plant Database. Erroneously reported for Tuscany, Italy (D. Viciani, University of Firenze, pers. comm.).
<i>Genista melia</i> Boiss.		GRC	NO EX ²⁴	Incorrect identification; the specimen identified as <i>G. melia</i> belongs to <i>G. triacanthos</i> Brot., a widespread species.	NO	0	0	Two ex situ collections of <i>G. triacanthos</i> from Spain and Portugal. <i>G. melia</i> is reported for Turkey ²¹ .
<i>Hieracium hethlandiae</i> (F.Hanb.) Pugsley		GRB	NO EX	The species is preserved ex situ and in situ.	YES	1	1	The species is cultivated by the Shetland Amenity Trust in Lerwick and reintroduced Paul Harvey (SAT) pers. comm.
<i>Hieracium tolstooi</i> Fen. & Zahn		ITA	EX ²⁵	No change	NO	0	0	
<i>Kunkeliella psilotoclada</i> (Svent.) Stearn		SPA	EX ⁹	No change	NO	0	0	
<i>Ligusticum albanicum</i> Jáv.		ALB	NO EX ²⁶	Rediscovered in the Prokletije and Korab mountains of Albania	NO	0	0	Legal protection and ex situ conservation is needed.
<i>Limonium catanense</i> (Tineo ex Lojac.) Brullo		ITA	EX ²⁵	No change	NO	0	0	
<i>Limonium cavanillesii</i> Erben		SPA	EX		NO	0	0	In ENSCOBASE an accession of <i>L. cavanillesii</i> should be attributed to <i>L. perplexum</i> . No ex situ collection available. E. Laguna pers. obs.
<i>Limonium dubyi</i> (Gren. & Godr.) Kuntze	<i>Limonium bellidifolium</i> (Gouan) Dumort.	FRA	NO EX ²⁷	Taxonomic revision. See column Synonym.	YES	9	0	<i>L. bellidifolium</i> is present all along the coast of France from Marseille to Spain.
<i>Limonium intermedium</i> (Guss.) Brullo		ITA	EX	Ex situ collection likely lost.	NO	0	0	The only ex situ accession for this species could not be verified.
<i>Limonium peucetium</i> Pignatti		ITA	EX	No recent observations.	NO	0	0	
<i>Lythrum linifolium</i> Kar.		HUN	NO EX	Incorrect identification: <i>L. linifolium</i> in Hungary should be ascribed to <i>L. borysthenticum</i> (Schrank) Litv.	YES	4	5	Ex situ collections here mentioned refer to <i>L. borysthenticum</i> a widespread species. <i>L. linifolium</i> is an Asian species. Z. Barina pers. obs.
<i>Myosotis ruscinonensis</i> Rouy	<i>Myosotis ramosissima</i> subsp. <i>lebelii</i> (Nyman) Blaise	FRA	NO EX	Taxonomic revision. See column Synonym.	NO	0	0	<i>M. ramosissima</i> occurs in southern France close to Montpellier and Perpignan with a few populations. Urgent ex situ conservation measures required for the subsp. <i>lebelii</i> .

<i>Nolletia chrysocomoides</i> (Desf.) Cass.		SPA	NO EX ²⁸	Incorrect identification; <i>N. chrysocomioides</i> in Spain should be ascribed to a new taxon: <i>Galatella malacitana</i> Blanca, Gavira & Suár.-Sant.	NO	0	0	<i>G. malacitana</i> is known from three small localities in the Malaga Province, Spain ²⁸ . Since the species was recently described (2015), legal protection, investigation of the distribution and ex situ conservation are required.
<i>Normania nava</i> (Webb & Berthel.) Franc.-Ort. & Lester		SPA	EX ⁹	No change	NO	0	0	
<i>Ornithogalum visianicum</i> Tomm.	<i>Loncomelos visianicum</i> (Tomm. ex Vis.) Speta	CRO	NO EX ²⁹	Rediscovered in the locus classicus: Island of Velika Palagruža, Croatia.	NO	0	1	Legal protection and urgent ex situ and in situ conservation measures are needed. A non-verified ex situ cultivation exists.
<i>Pharbitis preauxii</i> Webb		SPA	EX ⁹	No change	NO	0	0	
<i>Puccinellia gussonei</i> Parl.	<i>Puccinellia festuciformis</i> (Host) Parl. subsp. <i>lagascana</i> M.A.Juliá & J.M.Monts.	ITA	NO EX ³⁰	Taxonomic revision. See column synonym.	NO	0	0	
<i>Puccinellia pannonica</i> (Hack.) Holmberg		HUN	EX	No change	NO	0	0	The only known site of the occurrence has been built up and is a densely populated part of Budapest. Z. Barina pers. obs.
<i>Ranunculus fiorii</i> Pignatti		ITA	EX	No recent observations.	NO	0	0	
<i>Ranunculus fraelensis</i> Dunkel		ITA	EX	Habitat lost. See notes.	NO	0	0	The only known site of occurrence was inundated in 1953 after the construction of a dam.
<i>Ranunculus hostiliensis</i> Pignatti		ITA	EX ²⁵	No change	NO	0	0	
<i>Ranunculus mutinensis</i> Pignatti		ITA	EX ²⁵	No change	NO	0	0	
<i>Suaeda kocheri</i> Guss. ex C.Brullo, Brullo & Giusso		ITA	EX ²⁵	No change	NO	0	0	
<i>Tanacetum funkii</i> Sch.Bip. ex Willk. & Lange	<i>Anthemis funkii</i> (Sch.Bip. ex Willk. & Lange) Benedí.	SPA	EX ⁹	No change	NO	0	0	
<i>Vicia dennesiana</i> H.C.Watson		AZO	EX	No change. K. Freitas Pers. Comm.	NO	0	0	An accession reported on the BGCI database does not exist anymore. The DB will soon be updated.
<i>Viola cryana</i> Royer ex Gillot		FRA	EX ²⁷	No change	NO	0	0	